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although the money for this purpose is in the hands of the State treasurer. This money was saved from his meager appropriation by Professor Rominger, who thus offers to the Legislature a rare example of economy. The governing body of Michigan should recognize this fact by returning the money to their ex-State-geologist, and publishing the report without delay by a new appropriation. Professor Rominger has the endorsement of the geologists of the country.

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RECENT LITERATURE.

ROMANES' RESEARCHES ON THE NERVOUS SYSTEMS OF JELLY AND STAR-FISH.[1]—The beautiful researches and discovery by Haeckel of a nervous system in Geryonia, consisting of true ganglion cells and true nerve-fibers, and the extension by the Hertwig brothers of our knowledge of the nervous system of Medusæ in general, especially the naked-eyed forms, marked a most important step in animal morphology.

These microscopical observations were, except Haeckel's discovery, forestalled by the physiological experiments of Professor Eimer and Dr. Romanes, who, however, worked independently of each other. In the present work Dr. Romanes gives a popular account of his own researches, with due mention of and credit to Dr. Eimer's researches in the same direction.

After having some account of the structure of the Medusæ, we are afforded the results of fundamental experiments. The author proved that excision of the extreme margin of a nectocalyx (or umbrella) of the naked-eyed Medusæ causes immediate, total and permanent paralysis of the entire organ. This result is striking and decided. Indeed, adds the author, "I do not know of any case in the animal kingdom where the removal of a center of spontaneity causes so sudden and so complete a paralysis of the muscular system, there being no subsequent movements or twitchings of a reflex kind to disturb the absolute quiescence of the mutilated organism. The experiment is particularly beautiful if performed on Sarsia; for the members of this genus being remarkably active, the death-like stillness which results from the loss of so minute a portion of their substance is rendered by contrast the more surprising." On the other hand the severed margin "continues its rhythmical contractions with a vigor and a pertinacity not in the least impaired by its severance from the main organism, so that the contrast between the perfectly motionless swimming-bell and the active contractions of the thread-like portion which has just been removed from its margin is as striking a contrast as it is possible to conceive." But though in the vast majority of cases it was found that excision of the margin impairs or destroys the spontaneity of the animal for a time, the paralysis so produced was very seldom permanent. After a variable period occasional contractions are usually given, and in some cases they were resumed with but little apparent detriment.

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[1] *The International Scientific Series.* Jelly-fish, Star-fish and Sea-urchins. Being a research on primitive nervous systems. By GEORGE J. ROMANES, LL.D., F.R.S. New York, D. Appleton & Co., 1885. 12mo, pp. 323.

Light was found a most marked and unfailing stimulus, and light *per se*, rather than a sudden transition from darkness to light. Hence it was satisfactorily proved that the "eyes" of these animals are really such, as the following experiment with others, proves:

"Having put two or three hundred Sarsiæ into a large bell jar, I completely shut out the daylight from the room in which the jar was placed. By means of a dark lantern and a concentrating lens, I then cast a beam of light through the water in which the Sarsiæ were swimming. The effect upon the latter was most decided. From all parts of the bell-jar they crowded into the path of the beam, and were most numerous at that side of the jar which was nearest to the light. Indeed, close against the glass they formed an almost solid mass, which followed the light wherever it was moved. The individuals composing this mass dashed themselves against the glass nearest the light with a vigor and determination closely resembling the behavior of moths

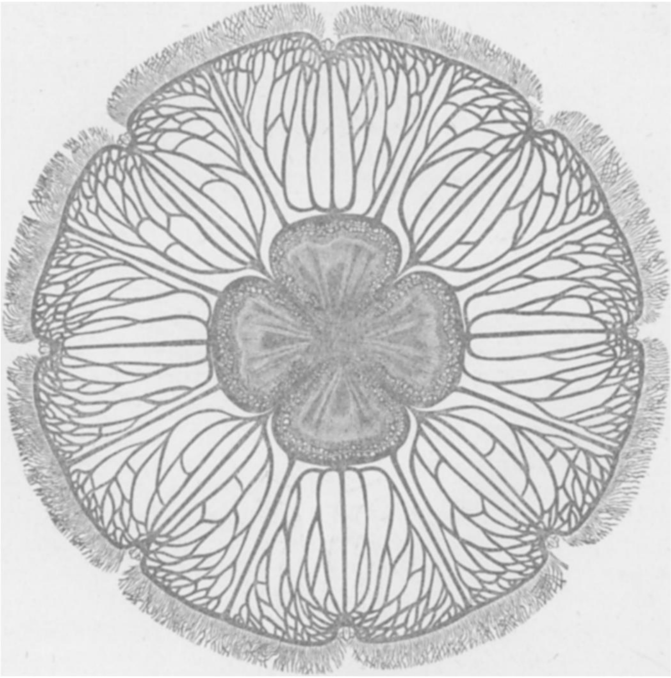

FIG. 1.—Aurelia aurita.

under similar circumstances. There can thus be no doubt about Sarsia possessing a visual sense."

Dr. Romanes then describes his experiments on the covered-eyed Medusæ to ascertain the amount of section which their neuro-muscular tissues will endure without suffering loss of their physiological continuity. In *Aurelia aurita* (Fig. 1) the nervous system is compared to a disk of muslin, the fibers and mesh of which are finer than those of the finest and closest cobweb, and if we imagine the mesh of these fibers to start from these marginal ganglia, we shall gain "a tolerably correct idea of the lowest nervous system in the animal kingdom." Now if seven of these eight ganglia are cut out, and the disk mutilated as in Fig. 2, yet the contraction waves, starting from the single ganglion left, "continued to zigzag round and round the entire series of sections."

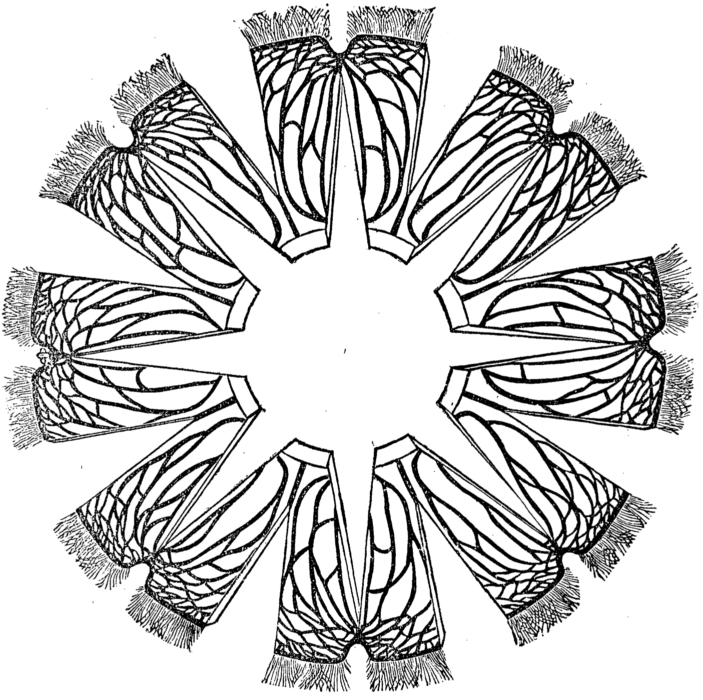

FIG. 2.—Aurelia, with its disk cut radially.

In a second mode of section (Fig. 3) the central space, *x*, was excised, the circular cut, z, made, leaving the isthmus, *z*, and all the eyes, or lithocysts, were removed except the one at *l*, yet the contraction waves, emanating from *l*, passed in the direction represented by the arrows without undergoing any appreciable loss of vigor. Upon completing the circular cut at *z*, the ring of tissue (*yz*) became totally paralyzed, while the outer circle, of course, continued its contractions as before.

Lastly a third mode of section was made (Fig. 4); a long strip removed, with the eye and its ganglion at one end and the rest of the swimming-bell at the other, the latter contracting, and such a strip may be made a yard long, but still the portion of the swimming-bell continues to contract. From these experiments and the histological studies of Professor Shäfer, it is seen that the "nerve fibers which so thickly overspread the muscular sheet of Aurelia do not constitute a true plexus, but that each fiber is comparatively short and nowhere joins with any of the other fibers; that is to say, although the constituent fibers of the network cross and recross one another in all directions—sometimes, indeed, twisting round one another like the strands of a rope—they can never be actually seen to join, but remain anatomically insulated throughout their length. So that the simile by which I have represented this nervous network—the simile, namely, of a sheet of muslin overspreading the whole of the muscular sheet—is, as a simile, even more accurate than has hitherto appeared; for just as in a piece of muslin the constituent threads, although frequently meeting one another, never actually coalesce, so in the

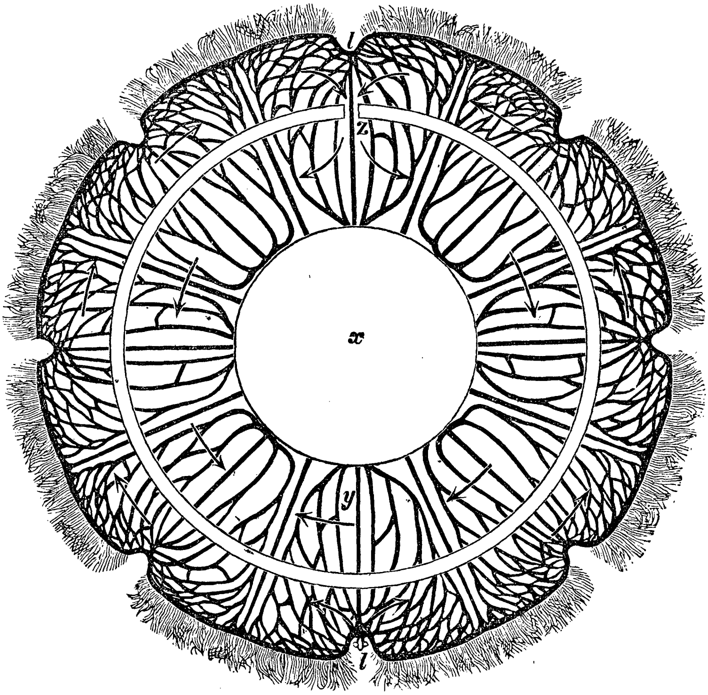

FIG. 3.—Aurelia with a circular cut *z*.

nervous network of Aurelia, the constituent fibers, although frequently in contact, never actually unite."

Space forbids farther abstracts of the book. The author discusses the regeneration of tissues, the excitable tissues of these animals regenerating themselves after injury with astonishing rapidity. Experiments were made in section of naked-eyed Medusæ; on the coördination of movements, and on the natural and artificial rhythm in the pulsations of Medusæ. The effect of poisons is discussed at length, particularly the effects of a change from salt water to fresh, as illustrated by the fresh-water Medusa, *Limnocodium sowerbii* (printed *sorbii*), of the tank in Regents Park (Fig. 5). It appears that a much less profound physiological change would be required to transmute a marine jelly-fish into a jelly-fish adapted to inhabit brine, than would be required to

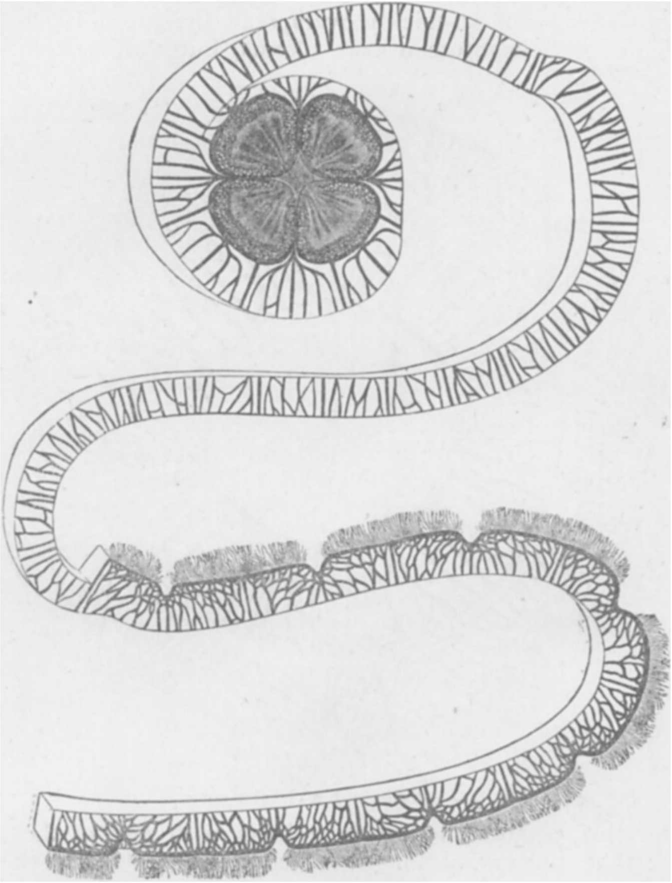

FIG. 4.—Third mode of section in Aurelia.

enable it to inhabit fresh water, and it is concluded: "If an animal so exceedingly intolerant of fresh water as is a marine jellyfish may yet have all its tissues changed so as to adapt them to thrive in fresh water, and even die after an exposure of one minute to their ancestral element, assuredly we can see no reason why any animal in earth or sea, or anywhere else, may not in time become fitted to change its element."

The book closes with an interesting chapter on the movements of star-fishes. And here it may be said that at the time this portion was written the later discoveries as to the nature of the nervous system of crinoids had not been published. It is now known, by the experiments of Marshall and Jickeli, as well as the histological investigations of the two Carpenters, that the visible nerves in crinoids belong to a general subcutaneous nervous sheet.

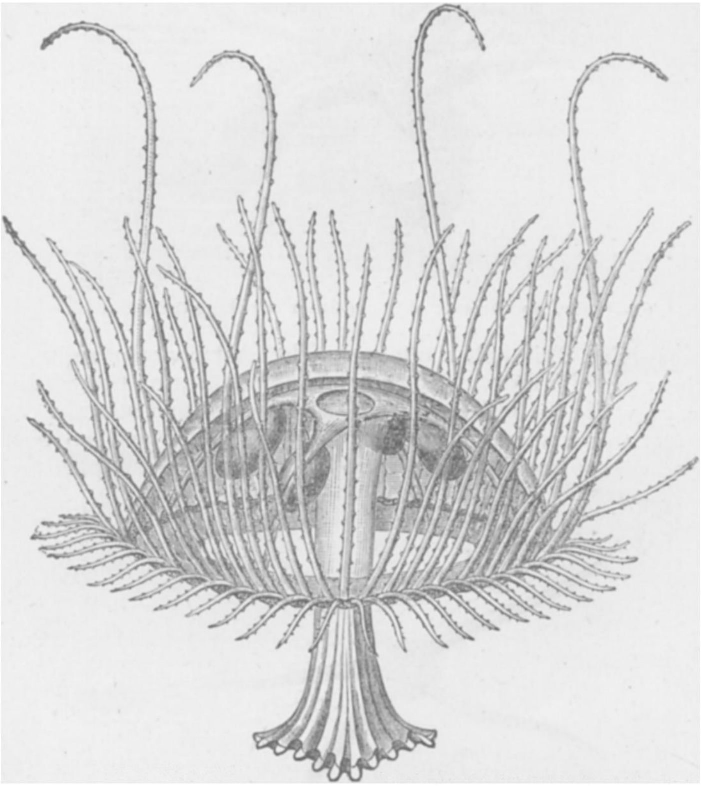

FIG. 5.—The fresh-water Medusa. Enlarged.

The well-known movements of the star-fish are then described and well illustrated (Fig. 6), as well as the natural movements of a brittle-star when proceeding along a solid horizontal surface (Fig. 7). All echinoderms when placed on their backs can right themselves, but different types have different ways of accomplishing this. The common star-fish does this by means of its suckers (Fig. 8) in half a minute. The Astropecten rights itself in the way here figured (Fig. 9). It stands on the tips of four of its rays, while the fifth one is thrown upwards and over the others, in order to carry with it the two adjacent rays, "and so eventually to overbalance the system round the fulcrum supplied by the tips of the other two rays, and thus bring the animal down upon its ventral surface."

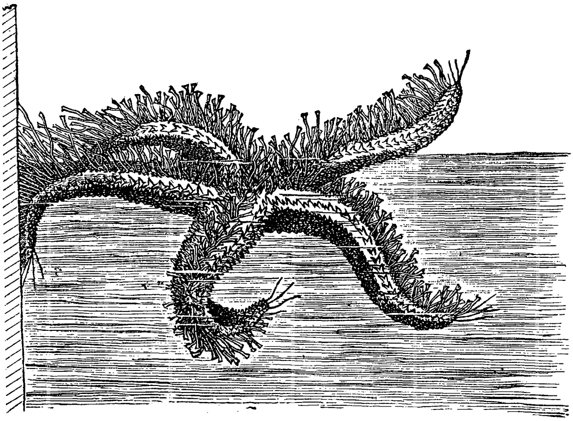

Fig. 6.—Natural movements of a star-fish on reaching the surface of water.

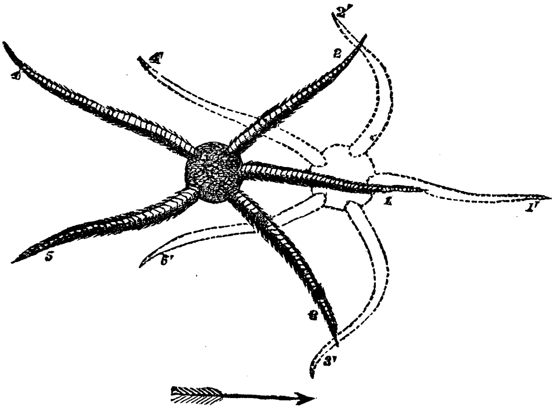

Fig. 7.—Natural movements of a brittle-star when proceeding along a solid horizontal surface.

Such movements are more difficult to perform in the sea-urchins, and only fresh and vigorous specimens can right themselves at all, owing to the heavy round body and feebler suckers. Fig. 10 represents one on its back with as many feet as possible protruded downwards and fastened firmly to the floor, "their combined action then serves to tilt the globe slightly over in their own direction, the anchoring feet on the other or opposite rows meanwhile releasing their hold of the tank to admit of this tilting. The effect of this tilting is to enable the next feet in the

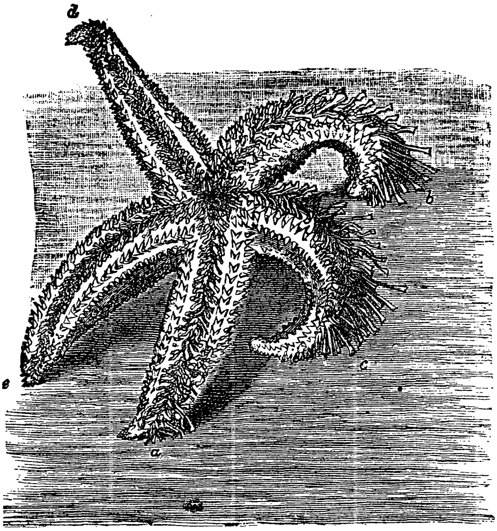

FIG. 8.—Natural righting movements of the common star-fish.

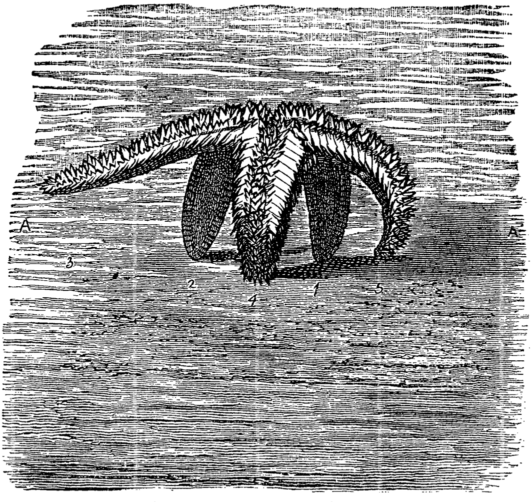

FIG. 9.—Righting movements of Astropecten.

active ambulacral rows to touch the floor of the tank, and when they have established their hold they assist in increasing the tilt; then the next feet in the series lay hold, and so on till the globe slowly but steadily rises upon its equator." Finally it lets itself down very slowly and carefully, the feet on one side preventing its too rapid descent (Fig. 11).

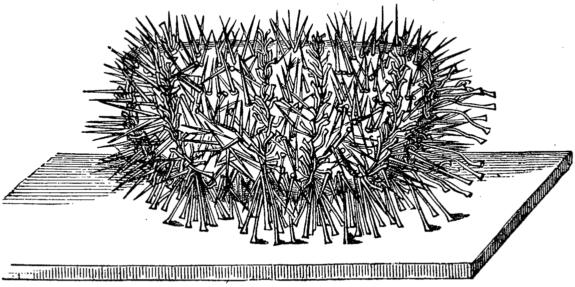

FIG. 10.—Echinus beginning to right itself.

Experiments on stimulation were made with the result of proving that the feet, spines and pedicellariæ are all highly coördinated in their action. Taking all the facts of stimulation together, it seemed probable that all these organs are "held in communication with one another by means of an external nervous plexus." Accordingly the author and Professor Ewarts went to work to see if they could obtain any microscopical evidence of such a plexus. This they succeeded in doing, and afterwards found that Professor Lòven had already briefly mentioned such a plexus as having been observed by him. The plexus consists of cells and fibers closely distributed all over the surface of the shell, immediately under the epidermal layer of cells (Figs. 12, 13), and it sends fibers all the way up the feet, spines and pedicellariæ. This important discovery led to further experiments on sections. It appears that single rays, when cut off from the body, crawl as fast and in as determinate a direc-

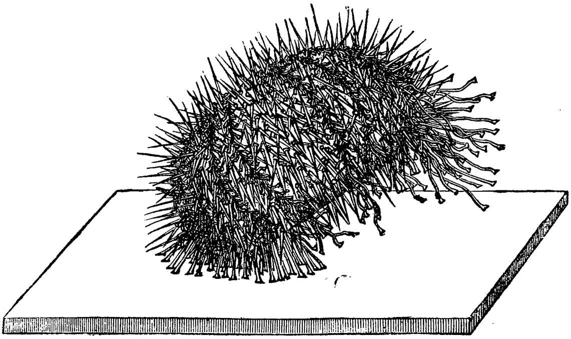

FIG. 11.—Echinus nearly righted.

tion as do the entire animals. They also crawl up perpendicular surfaces, and sometimes away from injuries, though not generally seeking to escape the latter as do the entire animals. By severing the nerves at the base of each of the five rays, or by dividing the nerve-ring between all the rays, the animal loses all power of coördination among its rays (Figs. 14, 15). If a continuous circular section of the external surface of the sea-urchin was made, it was invariably found that the spines and pedicellariæ within the circular area immediately respond to stimulation, while none outside the circle are affected. "These facts prove that the function which is manifested by these appendages of localizing and gathering round a seat of stimulation, is exclusively dependent upon the external nerve-plexus." From these and other experiments, and the histological studies of Professor Ewarts, it is concluded that the nervous system of an Echinus consists (1) of an external plexus which serves to unite all the feet, spines and pedicellariæ together, so that they all approximate a point of irritation situated anywhere in that plexus; (2) of an internal nervous plexus which is everywhere in communication through the thickness of the shell with the external, and the function of which is that of bringing the feet, spines and probably also the pedicellariæ into relation with the great coördinating nerve-center situated round the mouth; (3) of central nervous matter which is

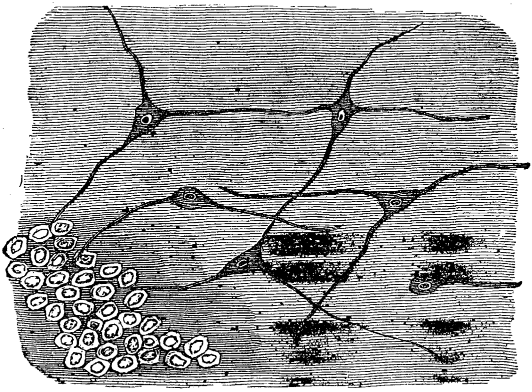

FIG. 12.—External nerve-plexus of Echinus.

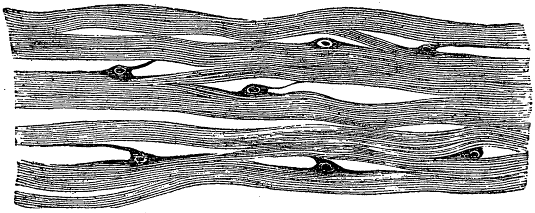

FIG. 13.—Structure of a nerve-trunk of Echinus.

mainly gathered round the mouth, and there presides exclusively over the coördinated action of the spines, and in large part also over the coördinated action of the feet, but which is further in part distributed along the courses of the main nerve-trunks, and so secures coördination of feet even in separated segments of the animal.

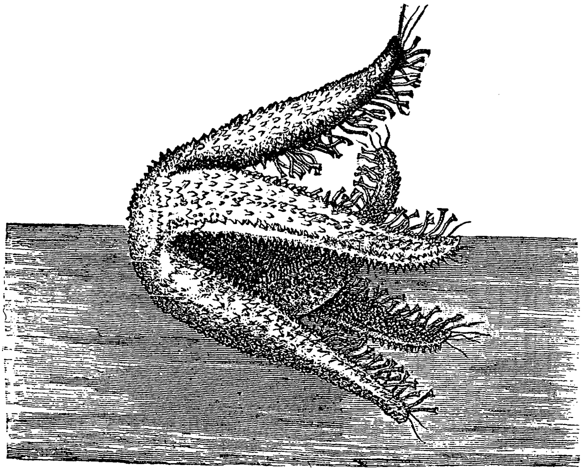

FIG. 14.—Uncoördinated movements of a star-fish in which the nerves of all the rays have been divided.

It was also determined that the so-called eyes of star-fish and sea-urchins were really such, as if a large tank be completely darkened except at one end where a narrow slit of light is admit-

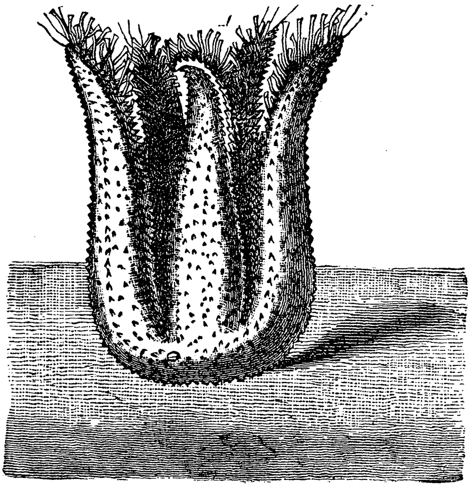

FIG. 15.—Posture frequently assumed when treated as in Fig. 14.

ted, and a number of star-fish and Echini be scattered over the floor of the tank, in a few hours almost the whole number will be found congregated in the narrow slit of light.

"On removing with a pointed scalpel the eye-spots from a number of star-fish and Echini without otherwise injuring the animals, the latter no longer crawled towards the light, even though this were admitted to the tank in abundance, but they crawled promiscuously in all directions. On the other hand, if only one out of the five eye-spots were left intact, the animals crawled towards the light as before. It may be added that single detached rays of star-fish and fifth-part segments of Echini crawl towards the light in the same manner as entire animals, provided, of course, that the eye-spot is not injured."

Finally, the presence of a sense of smell in star-fish which had been kept fasting for several days, was proved by presenting them with small pieces of shell fish. They immediately crawled to the food, and "if a small piece of the food were held in a pair of forceps and gently withdrawn as the star-fish approached it, the animal could be led about the floor of the tank in any direction." By progressively cutting off the rays and other experiments, it was found that the olfactory sense was equally distributed throughout their length, but along the lower surface.

These researches are certainly of much interest, and are positive additions to our knowledge of the nervous system and of the physiology of these types of life.

JORDAN'S CATALOGUE OF FISHES OF NORTH AMERICA.[1]—This catalogue will be a *sine qua non* of the ichthyologist. It is not only an index to the subject, but a good illustration of a generally rational nomenclature. The number of species now known is 1683. This number will be increased to a moderate extent from fresh and coast waters, and to a greater degree from deep-sea explorations. Thus the take of the Fish Commission steamer *Albatross*, for the past season includes seventy-five species which are not yet described.

Professor Jordan's efforts to do justice to honest work have been in the main successful. While employing such of the names of Rafinesque as are accompanied by recognizable indications; others formerly adopted are rejected, as resting on no sufficient evidence. We think, however, that in a few instances the author has gone a little further in favorable consideration of slip-shod work than justice to good work demands. Thus he adopts the two names Hypsoblennius and Reinhardtius, which were proposed without diagnosis or explanation, in preference to Isesthes and Platysomatichthys, which were defined when proposed. Professor Jordan has not previously taken this position, and he now informs

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[1] *Catalogue of the Fishes known to inhabit the waters of North America north of the Tropic of Cancer.* By D. S. JORDAN (Extracted from the Annual Report of the Commissioner of Fish and Fisheries for 1884). 1885, p. 185.